DTU Library

Electronics Department. Semi-annual report for the period 1 April - 30 September 1971

Research Establishment Risø, Roskilde

Publication date:
1972

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):
Research Establishment Risø, R. (1972). *Electronics Department. Semi-annual report for the period 1 April - 30 September 1971*. Risø-M No. 1467

Risö-M-1467

Danish Atomic Energy Commission

Research Establishment Risö

Risö-M-1467

ELECTRONICS DEPARTMENT

SEMI-ANNUAL REPORT FOR THE PERIOD
1 APRIL 1971 - 30 SEPTEMBER 1971

February 1972

k-1-72

Available on request from: Library of the Danish Atomic Energy Commission (Atomenergikommissionens Bibliotek), Risö, DK-4000 Roskilde, Denmark.
Telephone: [illegible], telex: [illegible]

A. E. K. Risø

Risø-M-1467

Risø-M-1467

Title and author(s)

Semi-annual Report for the Period
1 April 1971 - 30 September 1971

Date February 1972

Department or group

Electronics Department

Group's own registration number(s)

R-1-72

17 pages + tables + illustrations

Abstract

The report reviews the activities of the department in the **fields: instrumentation** for Risø experiments, systems techniques and nuclear geophysical methods. In a special chapther is treated maintenance and construction. Publications and lectures by staff members are listed.

Copies to

Abstract to

Available on request from the Library of the Danish Atomic Energy Commission (Atomenergikommissionens Bibliotek), Risø, Roskilde, Denmark. Telephone: (03) 35 51 01, ext. 334, telex: 5072.

ISBN 87 550 0129 7

CONTENTS

1. SYSTEMS TECHNIQUES

Work continued on the topics listed in ref. 7.

The HAMLET system for data collection on the alarm system of the DR-3 reactor was put in operation. Equipment failures caused some trouble during the period.

The general study of the control room at the DR-2 reactor was ended. This report presents the general results.

A new theme was treated: Will the EDP technique facilitate a more flexible documentation service at big plants? Proposals were worked out for cathode ray tube displays of the different systems for water, electricity, building plans, diagrams, etc. Methods for selecting the proper information are being investigated and a section treats the "Data bank".

The DR-2 computer system was demonstrated to people from power plants and industry as well as to visitors from abroad. At present work is concerned with detailed experimental planning.

A review of programming systems for minicomputers was initiated.

1.1. Reliability

In the field of reactor accident analysis we are specially concerned with the techniques used to assess the probability of occurrence of serious accident courses. It is necessary that representative models for prediction of the probability of relevant system or subsystem failure modes can be worked out and fitted together in an overall analysis.

Different kinds of discrete-state continuous time models were investigated with reference to development of analytical computer programs. Analytical studies of standby systems were of special interest. These often play an important role in large systems where a high degreee of reliability is required.

A standby model which directly generates the relevant system failure probabilities from arbitrary failure time and repair time distributions was developed by the cause/consequence diagram method, ref. 1. The main characteristic of this approach is that calculations of the system failure probabilities are carried out by considering the system failure states as compound-events. This leads directly to multiple integral expressions for the failure probabilities.

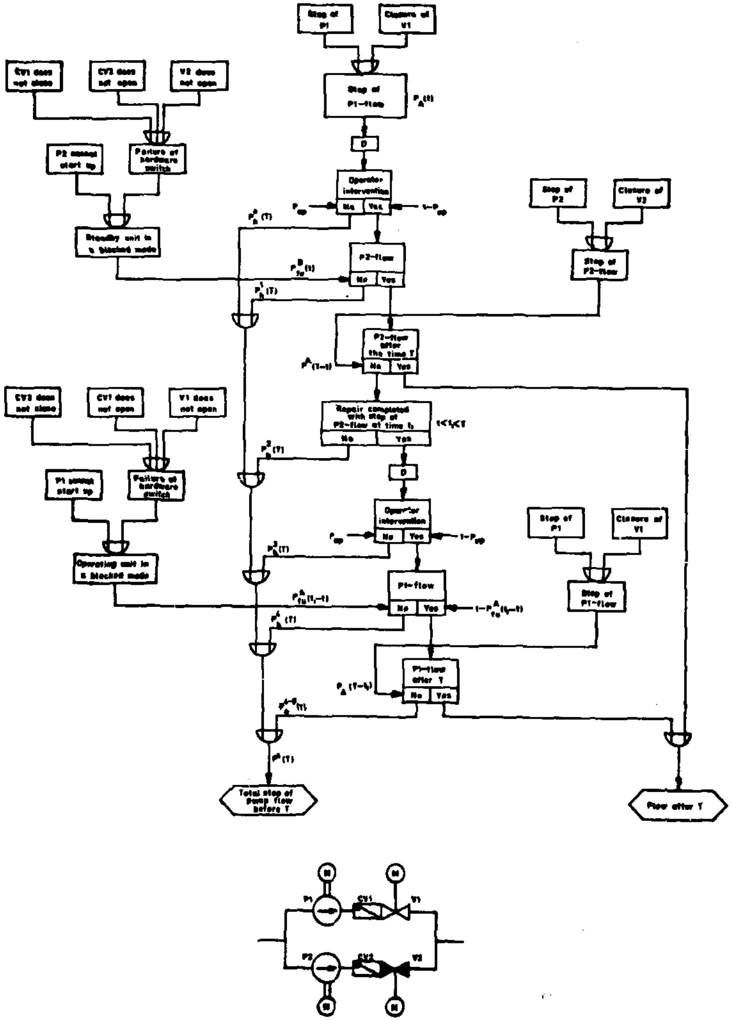

Fig.1. Cause/consequence diagram for a standby intermittently working system.

The cause/consequence diagram for a simple pump standby system is shown in fig. 1.

On the basis of the analytical study, a FORTRAN failure probability program was developed for the case of exponential distributions of failure times and repair times. An output example is shown in fig. 2.

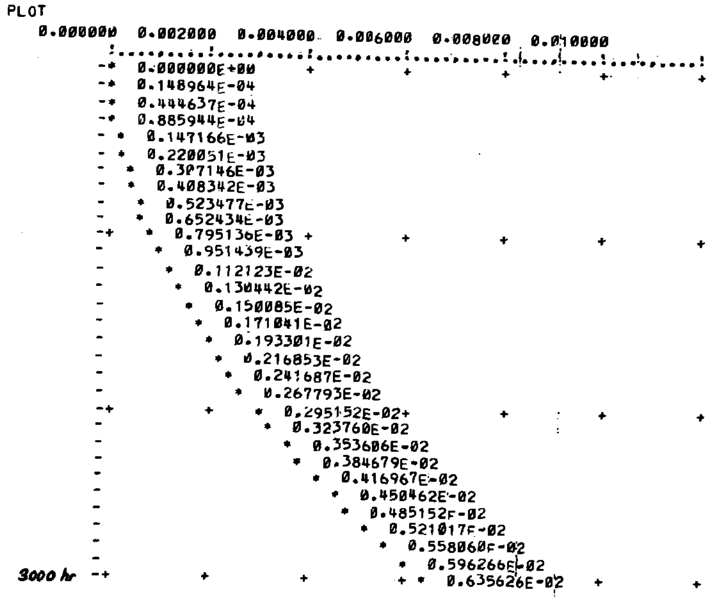

Fig. 2. Distribution function of standby system failure times (output from computer program).

1.2. Control Room Studies

An attempt to determine the mental models used in electronics trouble shooting has been described in ref. 7. The subjects were instructed to tell a tape recorder how they repaired oscilloscopes etc. - they were to "think aloud" during their work.

The control room study started with the same technique: a microphone and a recorder were installed in the control room of the DR-2 reactor. The initiative to start and stop the equipment was left completely to the operator in order that he should not feel forced by our study. After some weeks, the frequency of records was so much reduced that we tried to "inspire" the operator by letting the recorder start automatically when an alarm was announced. The operator could still stop the equipment whenever he would like to.

We learnt from this study that:

1. The DR-2 reactor has typically 10-20 alarms during one day of operation.
2. Most alarms serve as messages, an element of surprise is only seldom met, and consequently the operator reacts in a routine manner.
3. The meaning to the operator of a particular alarm depends very much on the situation (time in operation cycle).
4. The main part of the operator "verbalizations" occurred in connection with alarms, and this was the case also during the part of the study where he started the recorder himself. When left on, the equipment sometimes recorded conversation and discussions, and in this way it contributed a picture of the control room atmosphere.

Later, another method was introduced: observation by an engineer sitting behind the operator on duty and following the start-up of the reactor and the first hours of operation every day. The engineer is not to be an expert on reactor operation, he must rely only upon the face the process shows in the control room. He will gradually assimilate an operational model of the reactor process, and discusssions may begin with the operator within this sphere of concepts.

The observational study confirmed the former results and added some points:

1. The actual instrumentation layout contains several errors ranging from subtle details to unquestionable failures. An example of the latter is shown in fig. 3.
2. Human adaptability will compensate for even rather confusing task conditions.
3. There is a standard explanation of almost any behaviour of process and instrumentation.
4. Individual temperaments are reflected in different attitudes towards the same task. However, the differences are not so immediately reflected in the way of operation.

Both methods used in our study revealed important facts on the DR-2 control room. Particularly the last technique applied gave valuable experience on how the control room works. Several details were pointed out which deserve a further study, and we got some new ideas.

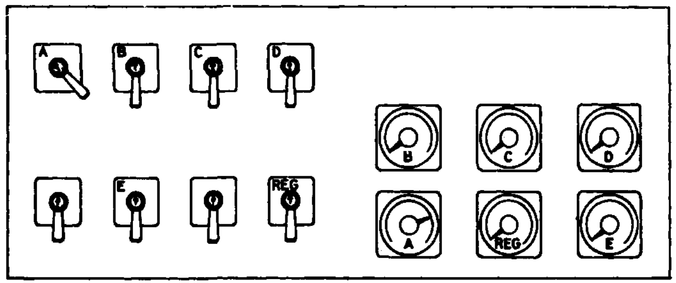

Fig. 3. Control rod manipulation at the DR-2 reactor: The bad correspondence between patterns of handles and meters violates basic ergonomic rules.

1.3. Computer Documentation of Large Plants

The documentation of a large plant is a comprehensive job. It is necessary to use many diagrams, tables, and card indexes.

Normally schematic diagrams are used to explain the technical functioning of the plant. Every diagram describes only a limited part of the plant and normally only one physical parameter, for instance water, air, or electric power.

In addition to the schematic diagrams it is necessary to use connection diagrams for the parts of the plant where there are many connections.

Each diagram must have many references to other diagrams in order to give a complete description of the whole plant. There are references from one subject on a diagram to the same subject on another diagram, but there are also references from one subject on a diagram to another subject on another diagram, and there must be references from schematic diagrams to connection diagrams and vice versa.

In addition to the diagrams tables and card indexes are generally used. They may contain further information, or they may be the guide to information.

Because of this, it is a difficult and expensive job to document a plant, but it is also difficult to use the documentation.

It should be possible to store all the information on a plant as data in a computer. The information from diagrams, tables, and card indexes should be placed in a data bank with references between related facts.

The large store capacity of a computer system and the high working speed should make it easy to store, change and retrieve information.

The computer must have a graphic terminal fitted with key board, light pen or some similar device.

The whole plant will be described as components with terminals. For every terminal there is information about connections to other terminals. Every component has a name, by means of which the graphic symbol of the component can be called and shown on the graphic terminal. The user adds components to the terminals of the first component, using the light pen. The diagrams can show different physical parameters, so that it is possible to understand the construction of the plant.

Many diagrams with information about certain parts of the plant have general interest. These diagramms will be fixed, and the data bank must be able to show one of them on a single order from the user. When the user has one of these diagrams, it should be possible for him to add more components to it.

The schematic diagrams are drawn as components the terminals of which are connected with lines. When the diagrams are made in that way, the computer must use some rules. There must be standard drawing rules for length of lines, orientation of components, and so on, but the user must be able to correct the drawing.

By means of the light pen it must be possible to move a component to another place, rotate it in the plane, and turn it about a vertical or horizontal axis.

The fixed diagrams with many components cannot be made with standard drawing rules only. Some special lines and components require separate rules to produce neat diagrams, these rules will be specific to the diagram in question.

The user may decide that connection diagrams of definite components are wanted. The information supplied by the schematic diagrams will be the basis for the connection diagrams. If the information from the schematic diagrams is not sufficient for the connection diagram, the computer will ask for further information when the user draws the component or a connection to the component on a schematic diagram.

Changes are to be made in one place only. In present systems for documentation it is necessary to add and modify information many places, and it is difficult to avoid errors.

A computer documentation system must also include a device which makes it possible to produce a hard copy of the diagram on the screen.

Rules for a small experimental data bank are now under development. The experiment will be carried out by means of the new graphical terminal in the Electronics Department. It will provide experience about applicability, rules for communication, rules for drawing, organization of data, and size of storage.

1.4. Hybrid Computer

The hybrid computer EAI 680/PDP8I was used for the simulation of chemical processes in connection with pulsed radiolyses. In addition calculation of membrane transport processes was carried out by the Chemistry Department.

A hybrid model of a boiling-water reactor was investigated for simulation of a complete power plant. The limited number of computing components in the analogue machine and the limited speed of the digital machine has until now restricted the model to a point model, but the main spatial effects on the dynamics were taken care of by means of variable weighting factors.

In connection with system program development a program (ref. 2) was made for the introduction of time-dependent data, for instance experimental data given as curves, into hybrid computation. The curves are traced automatically by an optical curve follower and are then, by patching of a few cords, introduced into the analogue circuit and can be shown on an oscilloscope display.

A course was arranged on analogue computer programming. In connection with this course a brief programming handbook was worked out (ref. 3) together with a set of problems.

The computer system has been frequently used by industrial firms.

1.5. Benson Boiler Model

For the study of self-organizing control of multi-variable processes a 200 MW Benson boiler was modelled (fig. 4). As the model should have two inputs and two outputs and should only describe the characteristic non-linearities and cross couplings, the following assumptions were made:

(a) Disturbances in a single boiler section propagate with infite velocity (point model).

(b) The heat capacity of tube walls in the evaporator is negligible, and the heat conductivity is infinite.

(c) The evaporator can be divided into two sections by a virtual surface (evaporating zone) which moves with changes in the load.

(d) Superheater and injection valves are excluded.

The resulting model covers the economizer and evaporator section.

From a controlling point of view the model has two inputs W: heating, and G: feed water flow. The aim of the controller is to compensate changes in steam pressure and temperature for changes in the load (steam consumption in turbine). The differential equations connecting the four state variables He, Q, P, and H_{f2} are non-linear. For investigation of the dynamic characteristics of the model at small variations around a working point, the model equations were linearized, and the corresponding transfer functions T(s)/W(s), T(s)/G(s), P(s)/W(s), and P(s)/G(s) were calculated. Fig. 5 shows steam temperature T and pressure P for a step change in feed water flow (G=5kg/s) and heating (W=10MW) when the boiler is fully loaded (W=200MW, G=100kg/s, T=386°C, P=170ato). The calculation of working points is based partly on requirements from the turbine and partly on experience.

Till now, the linearized model has been simulated on the analogue computer, later on the non-linear model will be investigated. The models are to be used for the study of "classic" decoupling methods and self-organizing control.

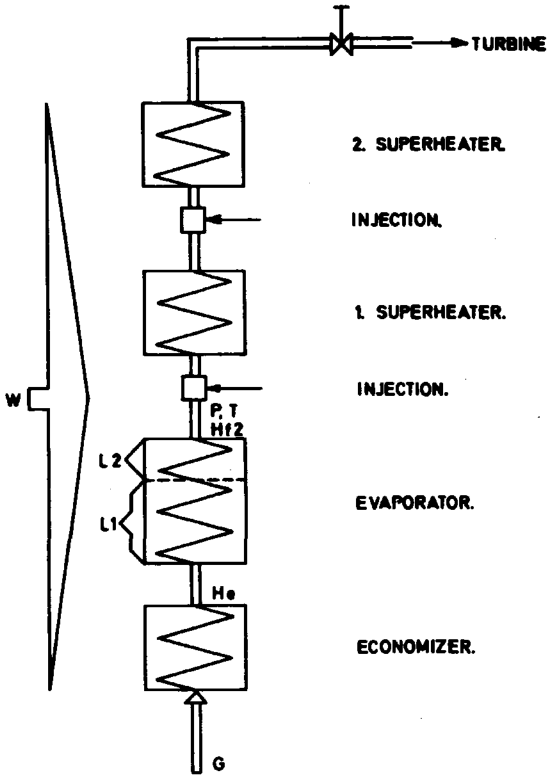

Fig. 4. Benson boiler (principles only)

G: Feedwater flow (kg/sek)

W: Heating (MW)

H_c: Enthalpy of feedwater in ~~economizer~~.

Q: Position of virtual evaporating zone $Q=l_1/l_1+l_2$

H_{f2}: Enthalpy of steam (kJ/hg) after evaporation

T: Steamtemperature (^{o}C) after evaporator

P: Steampressure (ato) after evaporator

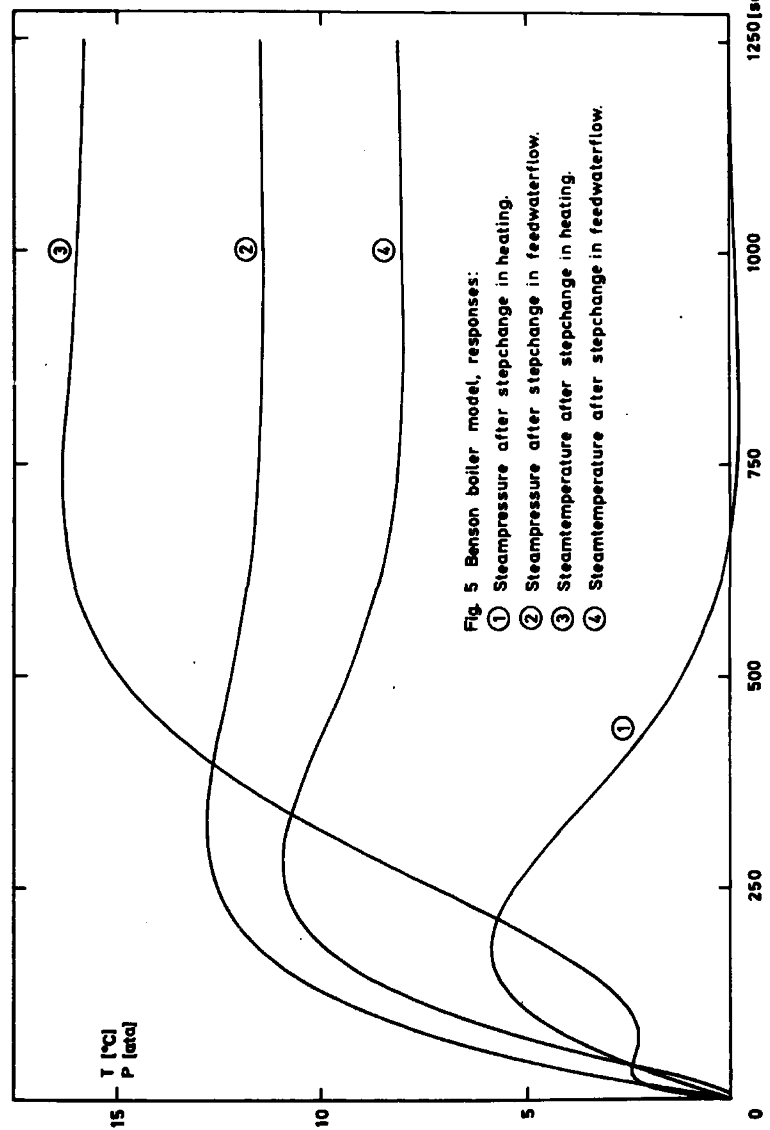

Fig. 5 Benson boiler model, responses:
1 Steampressure after stepchange in heating.
2 Steampressure after stepchange in feedwaterflow.
3 Steamtemperature after stepchange in heating.
4 Steamtemperature after stepchange in feedwaterflow.

2. NUCLEAR GEOPHYSICAL METHODS

Uranium Prospecting from the Air in Greenland

In July the Geological Survey of Greenland began prospecting from the air for uranium minerals in mid-eastern Greenland in co-operation with the Atomic Energy Commission. The instrumentation used was supplied by the Electronics Department and comprised a four-channel gamma spectrometer equipped with two 4 x 6" scintillation crystals. Gamma-spectrometric data covering about 7000 kilometres of flying distance were recorded from an altitude of 75 m or less at about 120 km/h. The data are now being processed with a view to the obtainment of a solid basis for the planning of a comprehensive future survey from the air.

X-Ray Fluorescence Analysis

The applicability of radioisotope-excited X-ray fluorescence analysis for in situ assessment of various metallic ores was studied in co-operation with A/S Nordisk Mineselskab. The field work was carried out in mid-eastern Greenland with an Ecko "Mineral Analyser". Our preliminary conclusion is that this kind of instrumentation improves the efficiency of mineral prospecting programmes in areas where no other analytical service is available.

Activation Analysis

We are extending the activities in the field of uranium assessment. After the design and construction of several laboratory gamma spectrometers for non-destructive determination of uranium, thorium, and potassium, we are designing an irradiation and counting facility for instalment at the DR-2 reactor. The facility will permit determination of uranium by delayed-neutron counting following neutron activation of 10 grammes of material. The advantage of this technique over gamma spectrometry is the direct measurement of uranium and the reduction of the time for a single analysis to about 3 minutes. The gamma spectrometers are, however, going to be used extensively, among other things because potassium and thorium are important elements in geochemical exploration work.

Seismometry

A radio-controlled firing system was developed for use with a commercial seismometer. The system releases explosive charges located up to appr. 12 km away from the seismometer. The system was succesfully used for seismic studies of sediments in western Greenland.

3. RESEARCH INSTRUMENTATION

Most of the jobs reported on in the last report(ref. 7) proceeded as planned. A nucleus density meter for air pollution measurements was developed and tested in the field. A Co-60 irradiation facility for the Statens Serum Institut was instrumented.

The Research Establishment Risø became a member of the ESONE Committee, and the delegate was appointed from the Research Instrumentationt Group. Two working group members, one of them the delegate, represent Risø in the CAMAC software and dataway groups. A Danish translation of the EUR 4100 report "CAMAC, A Modular Instrumentation System for Data Handling" is in preparation.

Most of the software for the new triple-axis spectrometer of the Neutron Physics Group, TAS-6, was developed. The prototypes of the CAMAC-modules to be produced by the department are ready after static testing by the Construction Group.

Most of the time spent on the running of the triple-axis spectrometers in the period was used for the revision of the TAS I spectrometer.

The mobile micrometeorological equipment is now being subjected to the final tests. A number of faults in the stationary equipment were traced to the cyclic-redundancy-check generator in the magnetic-tape station.

The programmes for the hot-wire heat transmission experiment of the Experimental Technology Section were improved.

Two improved Algol-programs were worked out for the processing of Na(J)-scintillation detector spectra. One is used for the calculation of area, peak position, resolution, etc., the other for the plotting of the spectrum and the data.

The final testing of the data handling system for the Isotope

Laboratory began in August. The two interfaces for the magnetic-tape stations were both finished and tested outside the system prior to their installation. A remote display for the digital clock was produced. One of the three multi-channel analysers to be used in the system was borrowed from the Isotope Laboratory for testing. The system is expected to be transferred to the Isotope Laboratory in 1972.

The 1024-channel analyser for the new gamma-detector system arrived in July, three months late, and was tested before installation. The Ge-detector of the system gave rise to considerable work as it was found impossible to obtain more than 75% of the efficiency stated by manufacturer. An X-ray showed the distance from the crystal to the front of the housing to be 50% larger than specified. The detector was finally replaced by the manufacturer.

The laser anemometry experiments continue as planned. A two-watt argon laser is now used as a supplement to the He-Ne laser. The possibilities of measuring different physical parameters by means of electromagnetic radiation were studied and a survey made of present and future laser applications at Risø.

3.1. Equipment for Air Pollution Measurement

The necessary electronics was supplied for a nucleus density meter developed by the Health Physics Department. The meter was field-tested during several flights over the inland ice of Greenland.

The meter consists of a cloud chamber and a light density meter, and it functions as follows:

The air sample is passed to a chamber, where the humidity is raised to 100%. The chamber is then expanded, and a cloud is formed with the pollution particles as condensation nuclei. A lamp at one end and a photodetector at the other end of the chamber permit measurement of the attenuation of the light caused by the cloud.

There is a linear relationship between the number of nuclei per ml and the derivative of the light attenuation, so we developed an instrument to measure that value. A block diagram of the instrument is shown in fig. 6.

The current to voltage converter provides a short circuit of

the photo cell to obtain a linear relation between light intensity and photocurrent. The sensitivity of the differentiation circuits is changed in steps of 1:10. To increase the noise immunity the analogue switch opens the measuring channel only during the first part of the expansion of the chamber.

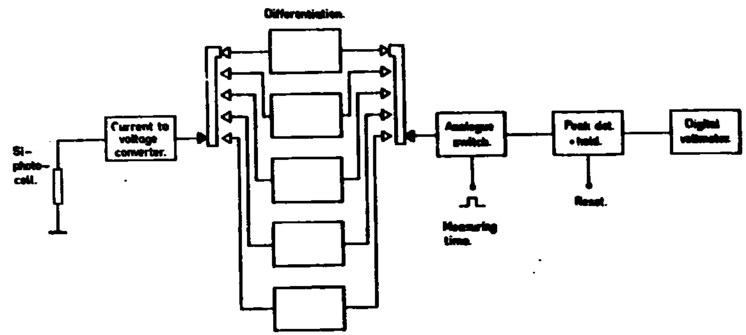

Figure 6: Analogue computer circuits for air pollution measurements.

Block diagram.

Fig. 7. 5000 Curie Co-60 irradiation facility

The Electronics Department supplied the instrumentation for a 5000 Curie Co-60 irradiation facility manufactured and installed by the Construction Department at the Statens Seruminstitut, Copenhagen. The instrumentation measures the total irradiation time, also in case of power failures.

4. MAINTENANCE AND CONSTRUCTION

On account of the increasing amount of electronic equipment in use at Risø it was found practical to carry out the production and maintenance work in a separate part of the Department. Earlier this work was performed by the various development groups. But, in the last years a reorganization has taken place, and a description is given here of the new structure and the work carried out in the production/maintenance sections.

The construction section is organized in four groups:

1. The planning group
2. The electronics workshop
3. The mechanical workshop
4. The drawing office

The planning group controls the project flow in the other three groups, so this group is actually the managing part of the section. Besides its important main job of control, it carries out much work in the areas of standardisation and circuit development. The last three groups are responsible for a proper standard of quality in the physical layout.

The maintenance section is responsible for the maintenance of most of the electronic equipment at Risø. The stock of equipment grows every year, so the maintenance section has a rather big and ever-growing job. This calls for efficiency and education. The section tries to meet this demand by developing new and more effective methods of performing maintenance and trouble shooting. The necessary education is partly provided by the staff itself.

Our experience is that this organization of the construction/maintenance section is effective.

LECTURES

20 August	L. Lading. Remote Measurement of Velocity, Temperature, and Density and Determination of Chemical Composition utilizing Laser Light. Seminar for the Meteorological group.
21 September	L. Løvborg, H. Kunzendorf. Application of Gamma Spectrometry. NATO Advanced Study Institute on the Prospecting for Uranium Minerals, London.
26 May	Dan S. Nielsen. The Cause/Consequence Diagram Method as a Basis for Quantitative Reliability Analysis. ENEA/CREST meeting in Munich: Applicability of Quantitative Reliability Analysis of Complex Systems and Nuclear Plants in its Relation to Safety.
8 September	Jens Rasmussen. Man as Information Receiver in Diagnostic Tasks. IEE Conference on Displays, Loughborough.
10 September	L. P. Goodstein. Operator Communications in Modern Process Plants. IEE Conference on Displays, Loughborough.
22 September	Bjørn Runge. Invisible ODT with Tracing Facilities. DECUS Seminar, Amsterdam, Holland.

PUBLICATIONS

1) Dan S. Nielsen. The Cause/Consequence Diagram Method as a Basis for Quantitative Accident Analysis. Risø-M-1374. (1971) 17 pp.

2) K. Søe Høberg. Time Function Generator, Multiple Time Function Generator, and Multiple Curve Follower, Programme for EAI 680/PDP8. Risø-M-1364. (1971) 20 pp.

3) K. Søe Højberg. Programmering af analogiregnemaskine (EAI 680). Risø-M-1408. (1971) 29 pp.

4) Lars Lading. Differential Doppler Heterodyning Technique. Appl. Opt. 10, (1971) 1943-1949.

5) L. Løvborg, H. Wollenberg, P. Sørensen, and J. Hansen. Field Determination of Uranium and Thorium by Gamma-Ray Spectrometry, Exemplified by Measurements in the Ilimaussaq Alkaline Intrusion, South Greenland. Econ. Geol. 66 (1971) 368-384.

6) L. Løvborg. Mineraleftersøgning i Grønland - kernefysiske målemetoder. AEK's årsberetning 1970/71, 19-25.

FURTHER REFERENCES

7) Semi-annual Report for the Period 1 October 1970 - 31 March 1971. Electronics Department. Risø-M-1430 (1971) 27 pp.